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(54) **PLASMA PROCESSING CHAMBER HAVING MAGNETIC ASSEMBLY AND METHOD**

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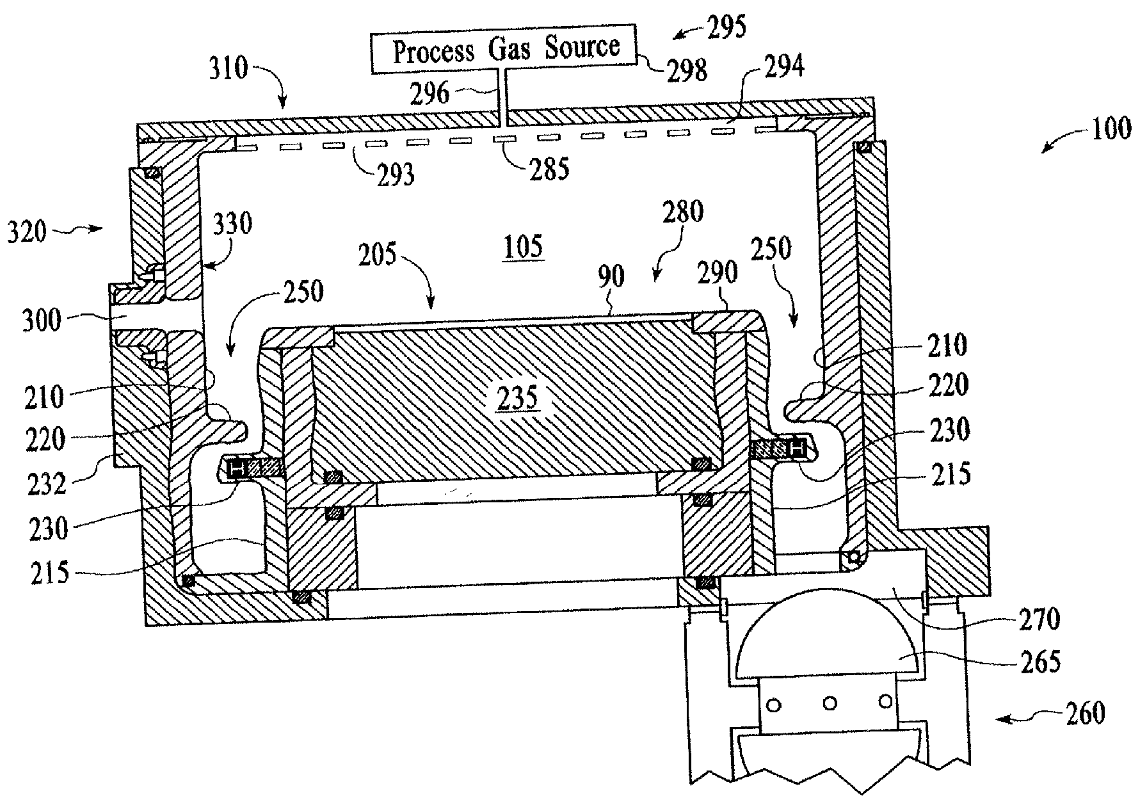
(57) **ABSTRACT**

A magnetic assembly for a plasma processing chamber includes an annular housing having a radially outward face and a radially inwardly facing opening, a cover plate to seal the radially inwardly facing opening, and a plurality of magnets in the annular housing. The magnets may be in preassembled modules that abut one another in a ring configuration within the annular housing. A plasma processing chamber using the magnetic assembly includes a substrate support that can fit in an inner radius of the magnetic assembly, a gas supply to maintain process gas at a pressure in the chamber, a gas energizer to energize the process gas, and an exhaust to exhaust the process gas.



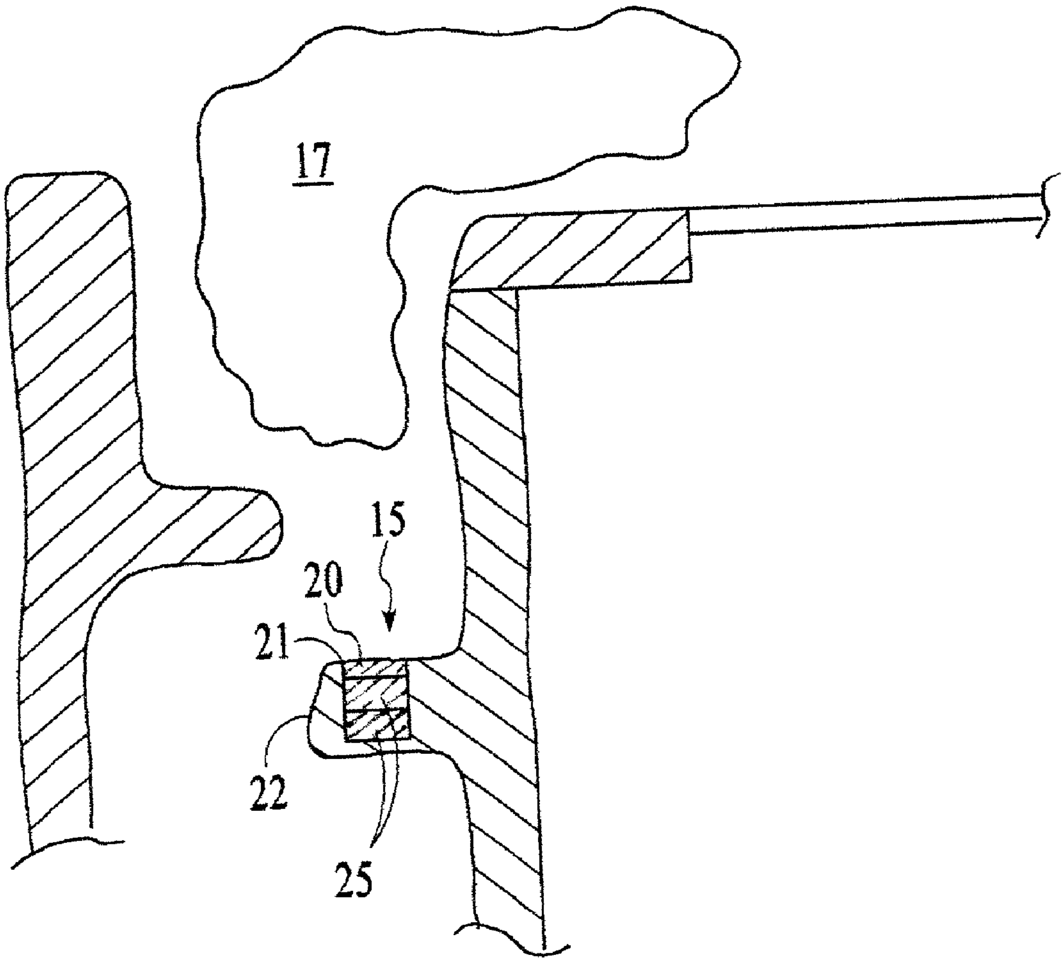


FIG. 1
(PRIOR ART)

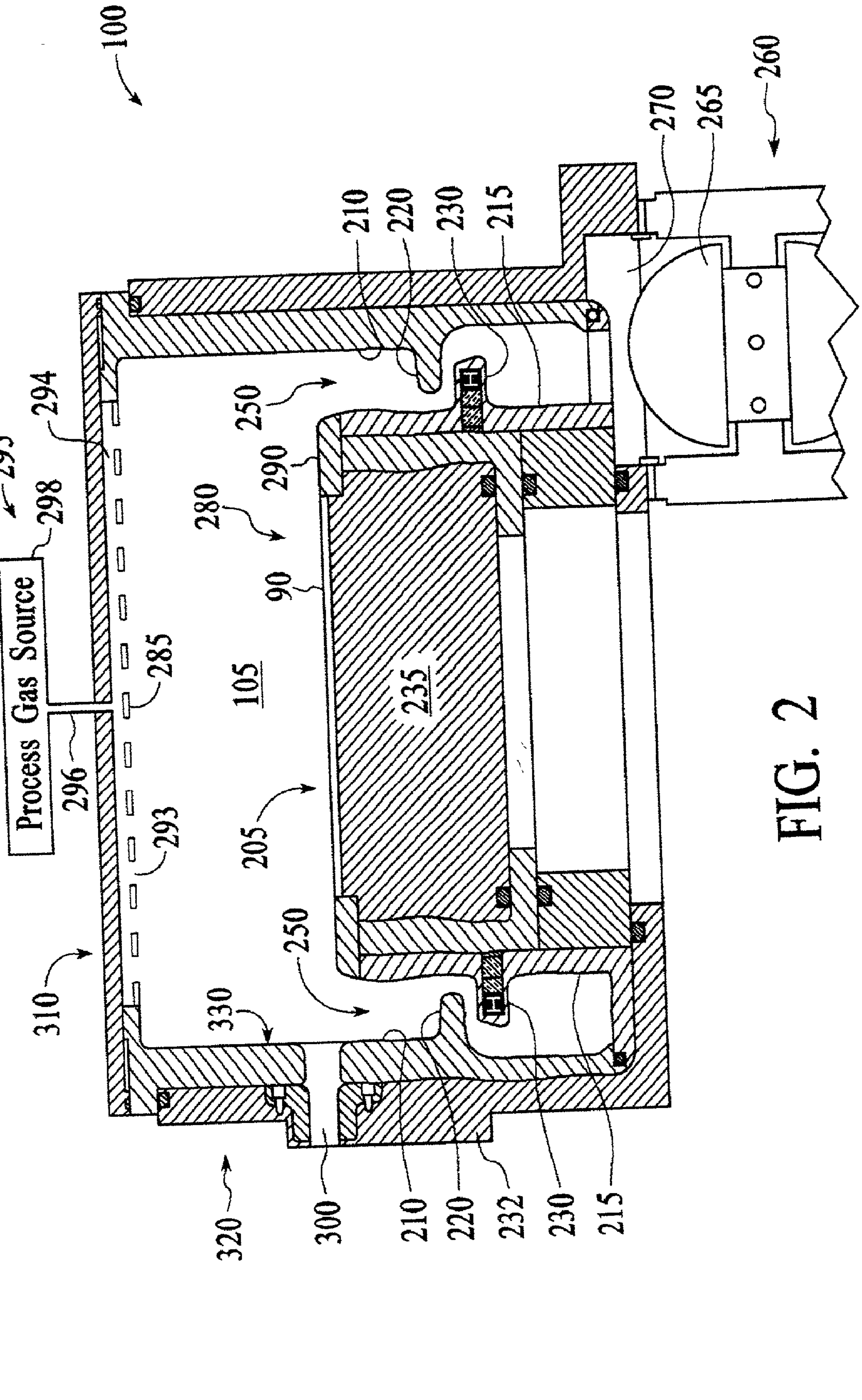

100
260
270
265
210
220
230
215
250
290
280
90
235
105
295
298
294
Process Gas Source
285
296
293
205
310
250
330
320
300
210
220
232
230
215

FIG. 2

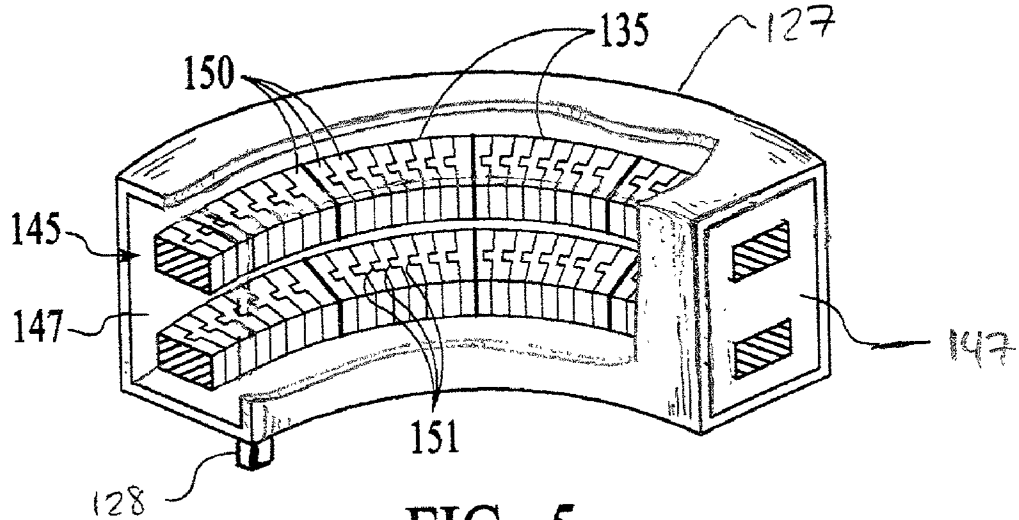

135
127
150
145
147
147
151
128

FIG. 5

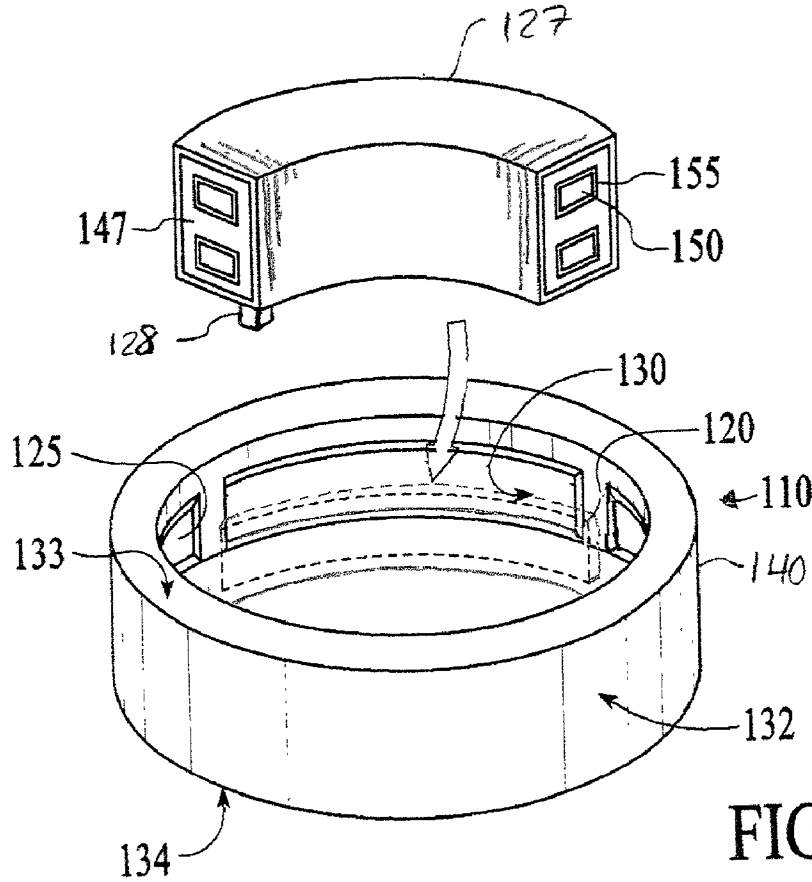

127
155
147
150
128
130
120
125
110
133
140
132
134

FIG. 3

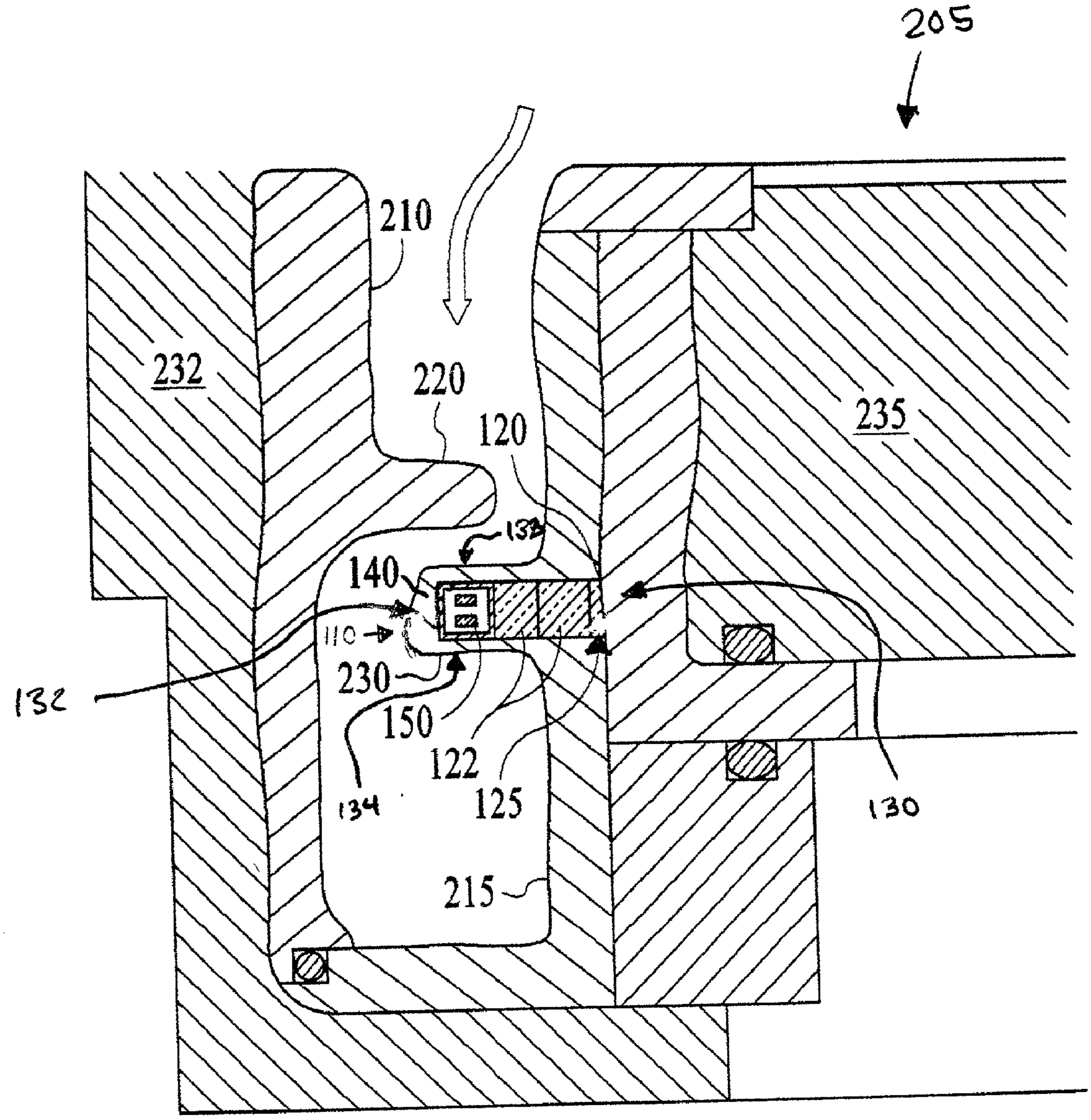

205
210
220
120
232
235
133
140
110
132
230
150
122
125
134
130
215

FIG. 4

PLASMA PROCESSING CHAMBER HAVING MAGNETIC ASSEMBLY AND METHOD

BACKGROUND

[**0001**] Embodiments of the present invention relate to a plasma processing chamber having a magnetic assembly and methods of manufacture.

[**0002**] A plasma processing chamber exposes a substrate to a plasma capable of processing the substrate. Typically, the chamber comprises a substrate support to support the substrate, a gas distributor to introduce process gas into the chamber, and a gas exhaust to exhaust the gas from the chamber. In certain chambers, a magnetic assembly is used to control the passage of plasma species into an exhaust channel of the chamber that may extend around the substrate support and is used to exhaust process gas from the chamber. For example, the magnetic assembly may be used to limit the passage of charged plasma species into the exhaust channel. The magnetic assembly may also be positioned around the substrate support to generate a magnetic field about the support to localize, excite, or contain the plasma, in or about the substrate processing zone in the chamber.

[**0003**] One type of magnetic assembly comprises a housing in which a number of permanent magnets are positioned as for example described in commonly assigned U.S. patent application No. 6,074,512 filed on Jul. 15th, 1997 to Collins et al. The magnets are sealed in an epoxy medium to prevent movement of the magnets within the housing. Typically, as shown in **FIG. 1**, the housing has a top or bottom opening **15** that is sealed by a cover plate **20** that is welded along its edges **21** to the sidewalls of the housing **22**. However, the welded interface **21** between the cover plate **20** and the housing **22** can erode when exposed to the plasma in the chamber. When holes are formed in the weld lines **21** or adjacent portions of the housing, the material inside the housing **22**, such as the epoxy that is used to hold the magnets **25** in place, can burn or otherwise deteriorate having undesirable effects on the substrate being processed and the magnetic assembly itself. For example, the magnets **25** can become damaged when the plasma **17** penetrates into the housing **22**. Permanent magnets which are made of rare earth containing materials are expensive and it would be desirable to remove the magnets from a damaged magnetic assembly and reuse the magnets. Thus it is desirable to have a magnetic assembly and housing that is more resistant to plasma erosion and that can be more easily used in refurbishment processes.

[**0004**] It is also difficult to manufacture such magnetic assemblies especially when a large number of magnets have to be precisely aligned to one another inside the housing. Often, some of the magnets become misaligned during assembly and this results in the magnetic assembly providing a undesirable magnetic field distribution. Thus, it is further desirable to have a magnetic assembly and manufacturing process that allows easier assembly and alignment of the magnets in the housing.

SUMMARY

[**0005**] A magnetic assembly for a plasma processing chamber, the magnetic assembly comprising:

[**0006**] (a) an annular housing having a radially outward face and a radially inwardly facing opening;

[**0007**] (b) a cover plate to seal the radially inwardly facing opening; and

[**0008**] (c) a plurality of magnets in the annular housing.

[**0009**] A magnetic assembly for a plasma processing chamber, the magnetic assembly comprising:

[**0010**] (a) an annular housing having a radially outward face and a radially inwardly facing opening;

[**0011**] (b) a cover plate joined to the housing to seal the radially inwardly facing opening; and

[**0012**] (c) a plurality of preassembled modules abutting one another in the annular housing, each preassembled module comprising a plurality of magnets.

[**0013**] A plasma processing chamber comprising the magnetic assembly of claim 9, the chamber comprising:

[**0014**] (i) a substrate support sized to fit within the magnetic assembly;

[**0015**] (ii) a gas supply to maintain process gas at a pressure in the chamber;

[**0016**] (iii) a gas energizer to energize the process gas to process the substrate; and

[**0017**] (iv) an exhaust to exhaust the process gas from the chamber.

[**0018**] A plasma processing chamber comprising:

[**0019**] (a) a magnetic assembly comprising:

[**0020**] (i) an annular housing having a radially outward face and a radially inwardly facing opening;

[**0021**] (ii) a cover plate joined to the housing to seal the radially inwardly facing opening; and

[**0022**] (iii) a plurality of preassembled modules abutting one another in a plurality of ring configurations, the ring configurations being stacked on one another in the annular housing, the preassembled modules abutting one another within each ring configuration, and each preassembled module comprising a plurality of magnets;

[**0023**] (b) a substrate support sized to fit within an inner radius of the magnetic assembly;

[**0024**] (c) a gas supply to maintain process gas at a pressure in the chamber;

[**0025**] (d) a gas energizer to energize the process gas to process the substrate; and

[**0026**] (e) an exhaust to exhaust the process gas from the chamber.

[**0027**] A method of manufacturing a magnetic assembly for a plasma processing chamber, the method comprising:

[**0028**] (a) providing an annular housing having a radially outward face and a radially inwardly facing opening;

[**0029**] (b) inserting a plurality of magnets into the annular housing through the radially inwardly facing opening; and

[0030] (c) joining a cover plate to the annular housing to seal the radially inwardly facing opening.

[0031] A method of refurbishing a magnetic assembly for a plasma processing chamber, the magnetic assembly comprising a first annular housing containing a plurality of preassembled modules comprising magnets, the first annular housing having a radially outward face and a radially inwardly facing opening, the radially inwardly facing opening sealed by a cover plate, the method comprising:

[0032] (a) removing the cover plate from the first annular housing;

[0033] (b) removing the preassembled modules from the first annular housing;

[0034] (c) inserting the preassembled modules into a second annular housing, the second annular housing having a radially outward face and a radially inwardly facing opening; and

[0035] (d) joining a second cover plate to the second annular housing.

DRAWINGS

[0036] These features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings which illustrate examples of the invention. However, it is to be understood that each of the features can be used in the invention in general, not merely in the context of the particular drawings, and the invention includes any combination of these features, where:

[0037] **FIG. 1** (Prior Art) is a cross-sectional side view of a portion of a plasma processing chamber having a conventional magnetic assembly;

[0038] **FIG. 2** is a cross-sectional side view of a plasma processing chamber having an embodiment of a magnetic assembly according to the present invention;

[0039] **FIG. 3** is an exploded perspective view of an embodiment of a magnetic assembly showing a preassembled module that fits in the annular housing of the magnetic assembly;

[0040] **FIG. 4** is a view of a portion of the chamber of **FIG. 2** showing the anode shield, cathode shield, and a magnetic assembly; and

[0041] **FIG. 5** is a perspective partial cut-out view of a portion of the magnetic assembly of **FIG. 3** showing preassembles modules abutting one another to form stacked rings of the modules within the annular housing of the magnetic assembly.

DESCRIPTION

[0042] A semiconductor fabrication process may be used to deposit material on or etch a substrate **90** in a plasma processing chamber **100**, such as for example, a DIELECTRIC ETCH MxP+ CENTURA chamber, commercially available from Applied Materials Inc., Santa Clara, Calif., as illustrated in **FIG. 2**. The particular embodiment of the process chamber **100** shown herein, which is suitable for processing of semiconductor substrates **90**, is provided only to illustrate the invention, and should not be used to limit the scope of the invention. Other process chambers capable of energizing a process gas, for example an IPS chamber, also available from Applied Materials Inc., can also be used. Generally, the chamber **100** comprises a substrate support **205** having a surface to support the substrate **90** in a process zone **105** of the chamber **100**. The substrate support **205** may comprise a quartz dielectric ring **290** that surrounds the substrate **90** to protect the underlying surface of the support **205** from the plasma. The substrate **90** is held in place during the process using a mechanical or electrostatic chuck having a receiving surface with grooves (not shown) in which a coolant gas, such as helium, is held to control the temperature of the substrate **90**. The chamber **100** encloses a process zone **105** with, for example, a top wall **310** and side walls **320**. An aperture **300** in the chamber **100**, such as in a side wall **320** as shown, is provided to allow the substrate **90** to be transferred into and out of the chamber **100**.

[0043] For example, to perform an etching process, the process chamber **100** is evacuated to a pressure of less than about 1 mTorr, and a substrate **90** is transferred to the substrate support **205** from a load lock transfer chamber (not shown), which is also at vacuum. The chamber **100** comprises a gas supply **295** to maintain a process gas at a suitable pressure in the chamber **100**. In one embodiment, the process chamber **100** is maintained at a pressure ranging from about 1 to about 1000 mTorr, such as from 10 to 300 mTorr. The process gas is introduced into the chamber **100** through a gas distributor **285** of a gas supply **295** comprising one or more gas lines **296** that connect a process gas source **298** to an inlet manifold **294** of the gas distributor **285** that conveys process gas through apertures **293** into the process zone **105**. The gas distributor **285** may comprise a showerhead plate that is located above the substrate **90** and is made from a dielectric material.

[0044] The chamber **100** further comprises a gas energizer **280** to energize the process gas to process the substrate **90**. Typically, the gas energizer **280** couples an electric field to the process gas in the process zone **105** to energize the process gas (i) inductively by applying an RF current to an inductor coil (not shown) encircling the process chamber **100**, (ii) capacitively by applying an RF current to a cathode electrode **235** and an anode electrode **232**, such as the side wall **320** (as shown), or (iii) both inductively and capacitively.

[0045] The gas energizer **280** comprises an RF power supply (not shown) to apply power to anode and cathode electrodes **232**, **235**. In reactive ion etching (RIE) processes, the gas energizer **280** typically energizes the process gas by capacitively coupling an RF voltage from the power supply to the cathode electrode **235** at a power level of from about 100 to about 2000 Watts, and by electrically grounding the anode electrode. Alternatively, an RF current at a power level of from about 750 Watts to about 2000 Watts can be applied to an inductor coil (not shown) to inductively couple energy into the process chamber **100** to energize the process gas in the process zone **105**. The frequency of the RF current applied to the process electrodes **232**, **235** or inductor coil is typically from about 50 kHz to about 60 MHz, such as about 13.56 MHz.

[0046] The plasma or energized process gas may be enhanced using electron cyclotron resonance or magnetically enhanced reactors, in which a magnetic field generator, such as electromagnetic coils, are used to apply a magnetic field to the plasma in the process zone **105** to increase the density and uniformity of the energized process gas. The magnetic field may comprise a rotating magnetic field with the axis of the field rotating parallel to the plane of the substrate **90**, as described in U.S. Pat. No. 4,842,683, issued Jun. 27, 1989, which is incorporated herein by reference. The magnetic field in the process chamber **100** may be sufficiently strong to enhance the plasma. For example, the magnetic field as measured on the substrate **90** may be less than about 500 Gauss, and more typically from about 10 to about 100 Gauss.

[**0047**] The gas supply **295** further comprises a gas exhaust **260** to exhaust spent process gas and etchant byproducts from the process chamber **100**. Typically, the gas supply **295** maintains a pressure of at least about 10^{-3} mTorr in the process zone **105**. The gas exhaust **260** comprises a vacuum pump **270** to pump the gas out of the chamber **100**. A throttle valve **265** is provided for controlling the pressure in the chamber **100** by regulating the flow of the gas between the process zone **105** and the vacuum pump **270**.

[**0048**] The plasma processing chamber **100** may also have an anode shield **210** adjacent to the anode **232** and a cathode shield **215** adjacent to the cathode **235** to shield the anode **232** and cathode **235** from the plasma. The shields **210, 215** facilitate a short "down time" when the processing chamber **100** is wet cleaned using a cleaning solution by protecting the anode **232** and cathode **235** from the cleaning solution. Additionally, the shields **210, 215** may be adapted to adjust a DC bias between the anode **232** and the cathode **235**. For example, the shields **210, 215** may be linings of which a surface area, thickness, or placement can be selected to obtain a suitable DC bias. One or more of the shields **210, 215** may comprise a dielectric material to electrically insulate the anode **232** and cathode **235** from the plasma. In the embodiment shown, one or more electrically conductive parts of the chamber walls **310, 320** serve as the anode **232**, and an electrically conductive electrode in the substrate support **205** serves as the cathode **235**. The anode shield **210** is an inwardly-facing lining at the top and sides of the chamber **100**. The cathode shield **215** lines the sides of the cathode **235** and thus the substrate support **205**. In one version, the shields **210, 215** comprise annular protrusions **220, 230** that function in combination as an exhaust baffle. For example, the annular protrusions **220, 230** may form an S-shaped channel therebetween to break the flow of gas to the gas exhaust **260**.

[**0049**] The plasma processing chamber **100** further comprises a magnetic assembly **110** comprising, as shown in **FIG. 3**, an annular housing **140** having a radially outward face **132** and a radially inwardly facing opening **130**, a cover plate **120** to seal the radially inwardly facing opening **130**, and a plurality of magnets **150** in the annular housing **140**. The radially inward facing opening **130** is sized to allow insertion of the magnets into the housing **140**. The annular housing **140** may further comprise top and bottom faces **133, 134**, wherein the radially outward face **132** extends from the top face **134** to the bottom face **133**, as for example, a continuous unitary structure that is substantially absent welds or other seams.

[**0050**] The magnetic assembly **110** typically serves to control a flow path or distribution of the plasma. For example, the magnetic assembly **110** may generate an increasing magnetic field in a path to the gas exhaust **260** to impede or altogether prevent the plasma from extending into the gas exhaust **260**. The annular housing **140** may have, for example, a cross-section that is U-shaped or C-shaped, where the concave opening **130** faces radially inwardly. In one embodiment, as shown in **FIG. 4**, the housing **140** is a protrusion **230** of the cathode shield **215**. In this embodiment, the cover plate **120** may be spaced from the magnets **150** by dielectric spacers **122**, made from a polymer or ceramic material.

[**0051**] The cover plate **120** is joined to the housing **140**, for example, by being welded or soldered to the housing **140**, to seal the opening **130**. For example, the cover plate **120** may be electron beam welded to the housing **140** by directing an electron beam at an interface between the housing **140** and the cover plate **120** to heat the material at the interface. When the material is sufficiently heated that it melts, the cover plate **120** is pressed onto the housing **140** and the interface material is allowed to cool and solidify. In another embodiment, the cover plate **120** is laser beam welded to the housing **140**, which comprises directing a laser beam to the interface between the housing **140** and the cover plate **120**. One or more of the housing **140** or cover plate **120** may comprise aluminum to facilitate the welding of the cover plate **120** to the housing **140**. In one embodiment, the housing **140** is made of aluminum 6000 and the cover plate **120** is made of aluminum 4000 to facilitate the welding.

[**0052**] The magnets **150** may be arranged in one or more preassembled modules **135**, as illustrated in **FIG. 4**. In one embodiment, each preassembled module **135** comprises from about 20 to about 40 magnets **150**. The number of modules **135** may be from about 3 to about 8, such as for example, about 4. For example, if there are a total of about 80 magnets **150** to be placed into four modules, each module **135** would contain 20 magnets **150**. The magnets **150** are placed typically abutting one another along an arc-shaped path in the module **135**. For example, the magnets **150** may be oriented so that their magnetic north/south poles lie along the arc. In one embodiment, the preassembled modules **135** comprise ring segments containing the magnets **150** abutting one another in a partial ring shaped configuration. In one version, one or more magnetic segments **127** contain preassembled modules **135** arranged in a plurality of ring configurations **145** stacked one above the other. The modules **135** arranged in the ring configurations **145** may be interspaced by portions of the magnetic segments **127**. The magnetic segments **127** are inserted into the housing **140** to provide a magnetic field that is substantially parallel to the path of the magnets **150** and with increased relative magnetic field strength closer to the annular housing **140**.

[**0053**] The magnets **150** typically comprise a ferromagnet material, such as a rare earth metal. The rare earth metal is able to generate a strong magnetic field relative to the amount used. For example, the magnets **150** may comprise neodymium. In one embodiment, the magnets **150** are held in each preassembled module **135** by a shrink-wrap material **155** around the magnets **150**. For example, the shrink-wrap material **155** may comprise polyolefin, teflon (TM), or silicone, which are commercially available from distributors such as Lance Wire & Cable, Inc., Clarkston, Ga., and R. S. Hughe, Sunnyvale, Calif. The magnets **150** are placed in a tube of the shrink-wrap material **155**. Then, if the shrink-wrap material **155** is a thermal material, the shrink-wrap material **155** is heated to cause it to contract around the magnets **150**. If the shrink-wrap material **155** is a mechanical material, the shrink-wrap material **155** is pressed onto the sides of the magnets **150** to mold it against the magnets **150**. The shrink-wrap material **155** improves physical support of the magnets **150** inside the module **135** and thermal distribution in the module **135**.

[**0054**] A filler **147** may be provided in the magnetic segments **127** to space or support the preassembled modules **135**. In one embodiment, the filler **147** comprises a dielectric material. The filler **147** may abut or surround the magnets **150**. In one version, the magnets **150** also comprise keys **151** to align the magnets **150** in the modules **135** and to maintain proper magnetic polarity. For example, this module key **151** may comprise an offset slot or protrusion of the magnet **150** that interlocks with another offset slot or protrusion of another magnet **150**. The magnetic segments **127** may also comprise keys **128** that fit to matching slots in the annular housing **140**. These alignment keys **128** ensure that the magnetic segments **127** can be positioned when being inserted in the annular housing **140**—with proper alignment and magnetic pole orientation.

[**0055**] The substrate support **205** may be sized to fit within an inner radius of the magnetic assembly **110** so that the magnetic assembly **110** encircles the support **205**. For example, the housing **140** of the magnetic assembly **110** may comprise the cathode shield **215** and the magnetic segments **127** may be inserted in an opening **135** of the cathode shield **215**. In the arrangement shown, the magnetic assembly **110** is near an exhaust path **250** of the gas exhaust **260** to generate a strong magnetic field therein, as shown in **FIG. 4**, impeding the plasma from escaping from the process zone **105** through the exhaust path **250**. When the plasma encounters an increasing magnetic field, it is repelled and the magnetic assembly **110** thus serves as an obstruction to the plasma. The magnetic assembly **110** according to the present invention is less susceptible to erosion than the conventional magnetic assembly because the seal line **125** between the housing **140** and the cover plate **120** is not exposed to the plasma. Instead, the seal line **125** abuts the substrate support **205**, preventing the plasma from reaching the seal line **125**.

[**0056**] In one version, conductive inner surfaces **330** of the plasma processing chamber **100** are anodized with a protective layer to prevent arcing to the conductive surfaces and to protect the surfaces **330** from erosion by the plasma. In the conventional magnetic assembly (not shown), the surface area of the weld line is difficult to anodize because of the inhomogeneity of the weld line to the surrounding area. In contrast, in the magnetic assembly **110** of the present invention, the seal line **125** between the housing **140** and the cover plate **120** is unexposed to the plasma, so the exposed area can easily be anodized with a protective layer (not shown).

[**0057**] The magnetic assembly **110** may be refurbished for the plasma processing chamber **100**. This refurbishment may comprise, for example, removing the modules **135** from an old annular housing **140** and inserting them in a new annular housing **140**. The annular housing **140** and magnetic segments **127** sufficiently protect the modules **135** from exposure to plasma, so the magnets **150** can be reused. First, the cover plate is removed from the first annular housing, and the modules **135** are removed from the first annular housing. Then, the modules **135** are inserted into a second annular housing **140**, and a second cover plate is bonded to the second annular housing. Typically, the preassembled modules **135** are exchanged between the old and new annular housings by exchanging the magnetic segments **127** containing the preassembled modules **135**. In one embodiment, the first annular housing is refinished to form the second annular housing. The first cover plate may also be refinished to form the second cover plate.

[**0058**] Thus, the present plasma processing chamber **100** and method is advantageous because it allows for improved processing of the substrate. Although the present invention has been described in considerable detail with regard to certain preferred versions thereof, other versions are possible. For example, the present invention could be used in a process chamber to deposit a material on a substrate. Thus, the appended claims should not be limited to the description of the preferred versions contained herein.

What is claimed is:

1. A magnetic assembly for a plasma processing chamber, the magnetic assembly comprising:

(a) an annular housing having a radially outward face and a radially inwardly facing opening;

(b) a cover plate to seal the radially inwardly facing opening; and

(c) a plurality of magnets in the annular housing.

2. A magnetic assembly according to claim 1 wherein the annular housing further comprises top and bottom faces, and wherein the radially outward face extends from the top face to the bottom face as a continuous unitary structure.

3. A magnetic assembly according to claim 1 wherein the radially inwardly facing opening is sized to allow insertion of the magnets into the annular housing.

4. A magnetic assembly according to claim 1 wherein the magnets are arranged in one or more preassembled modules, and wherein the radially inwardly facing opening is sized to allow insertion of the preassembled modules into the housing.

5. A magnetic assembly according to claim 4 wherein the preassembled modules abut one another in a ring configuration.

6. A magnetic assembly according to claim 5 further comprising dielectric spacers between the cover plate and the preassembled modules.

7. A magnetic assembly according to claim 4 wherein the magnets are held in each preassembled module by a shrink-wrap material around the magnets.

8. A magnetic assembly according to claim 4 wherein a plurality of the preassembled modules are arranged in a magnetic segment, and the magnetic segment comprises a key to align the magnetic segment in the annular housing.

9. A plasma processing chamber comprising the magnetic assembly of claim 1, the chamber comprising:

(i) a substrate support sized to fit within an inner radius of the magnetic assembly;

(ii) a gas supply to maintain process gas at a pressure in the chamber;

(iii) a gas energizer to energize the process gas to process the substrate; and

(iv) an exhaust to exhaust the process gas from the chamber.

10. A magnetic assembly for a plasma processing chamber, the magnetic assembly comprising:

(a) an annular housing having a radially outward face and a radially inwardly facing opening;

(b) a cover plate joined to the housing to seal the radially inwardly facing opening; and

(c) a plurality of preassembled modules abutting one another in the annular housing, each preassembled module comprising a plurality of magnets.

11. A magnetic assembly according to claim 10 wherein the preassembled modules comprise ring segments.

12. A magnetic assembly according to claim 11 wherein the preassembled modules are arranged in a plurality of ring configurations that are stacked on one another.

13. A magnetic assembly according to claim 10 comprising a plurality of magnetic segments that contain the preassembled modules, the magnetic segments comprising keys for aligning the magnetic segments in the annular housing.

14. A plasma processing chamber comprising the magnetic assembly of claim 9, the chamber comprising:

(i) a substrate support sized to fit within the magnetic assembly;

(ii) a gas supply to maintain process gas at a pressure in the chamber;

(iii) a gas energizer to energize the process gas to process the substrate; and

(iv) an exhaust to exhaust the process gas from the chamber.

15. A plasma processing chamber comprising:

(a) a magnetic assembly comprising:

(i) an annular housing having a radially outward face and a radially inwardly facing opening;

(ii) a cover plate joined to the housing to seal the radially inwardly facing opening; and

(iii) a plurality of preassembled modules abutting one another in a plurality of ring configurations, the ring configurations being stacked on one another in the annular housing, the preassembled modules abutting one another within each ring configuration, and each preassembled module comprising a plurality of magnets;

(b) a substrate support sized to fit within an inner radius of the magnetic assembly;

(c) a gas supply to maintain process gas at a pressure in the chamber;

(d) a gas energizer to energize the process gas to process the substrate; and

(e) an exhaust to exhaust the process gas from the chamber.

16. A method of manufacturing a magnetic assembly for a plasma processing chamber, the method comprising:

(a) providing an annular housing having a radially outward face and a radially inwardly facing opening;

(b) inserting a plurality of magnets into the annular housing through the radially inwardly facing opening; and

(c) joining a cover plate to the annular housing to seal the radially inwardly facing opening.

17. A method according to claim 16 wherein (b) comprises inserting a preassembled module comprising the magnets into the annular housing through the radially inwardly facing opening.

18. A method according to claim 16 comprising joining the cover plate to the annular housing by electron beam welding.

19. A method of refurbishing a magnetic assembly for a plasma processing chamber, the magnetic assembly comprising a first annular housing containing a plurality of preassembled modules comprising magnets, the first annular housing having a radially outward face and a radially inwardly facing opening, the radially inwardly facing opening sealed by a cover plate, the method comprising:

(a) removing the cover plate from the first annular housing;

(b) removing the preassembled modules from the first annular housing;

(c) inserting the preassembled modules into a second annular housing, the second annular housing having a radially outward face and a radially inwardly facing opening; and

(d) joining a second cover plate to the second annular housing.

20. A method according to claim 19 comprising refinishing the first annular housing to form the second annular housing, refinishing the first cover plate to form the second cover plate, and joining the second cover plate to the second annular housing by electron beam welding.

* * * * *